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F16H 25/24

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(56) Documents Cited
GB 1281143 A GB 0790487 A EP 0122598 A1
US 4856356 A US 4322987 A

(58) Field of Search
UK CL (Edition L) F2Q
INT CL[5] F16H 25/20 25/24

(54) Bearing screw and nut assembly

(57) A bearing screw comprises a screw member 30 extending through a nut member 32 which is axially movable with respect to the screw member. The screw member 30 has an external thread and the nut member 32 is provided with a pair of bearings 31 disposed in the interior thereof she inner ring 312 of each bearing has annular grooves 313 to engage the external thread of the screw member and the inner diameter of the inner rings of the bearings is larger than the outer diameter of the screw member so as to have the bearings eccentric to the screw member in opposite directions and partially engagable with the external thread of the screw member to transform the rotational motion of the screw member about the center axis thereof into the linear motion of the nut member along the center axis of the screw member. The bearings 31 may be double-row ball bearings or double-row roller bearings (Fig. 4 not shown).

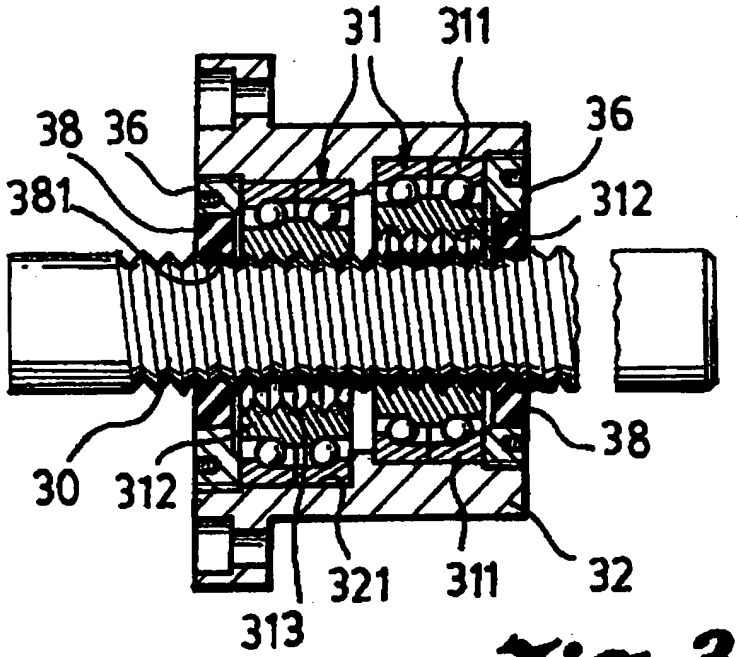

Fig. 3

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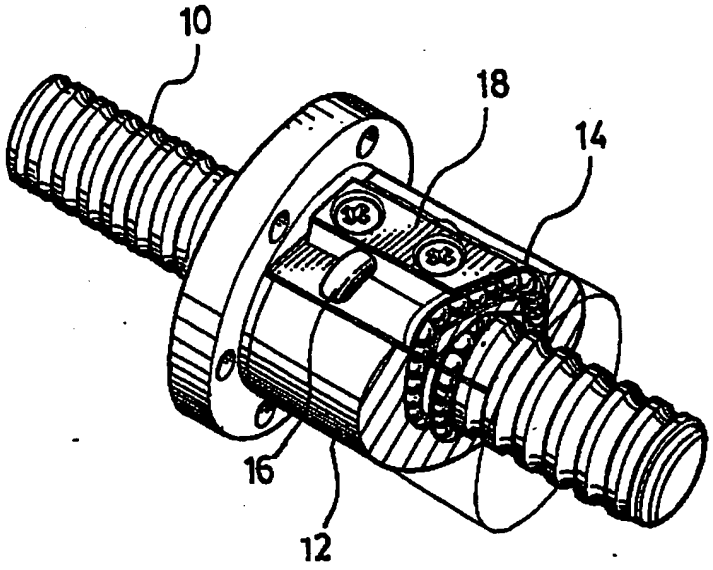

Fig. 1
(prior art)

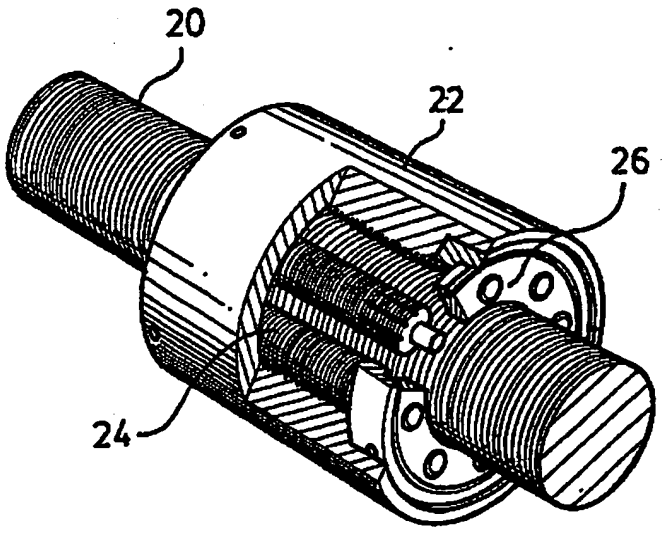

Fig. 2
(prior art)

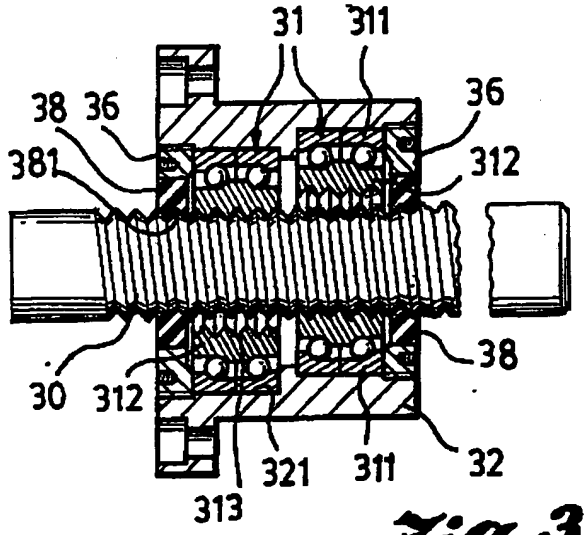
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Fig. 3

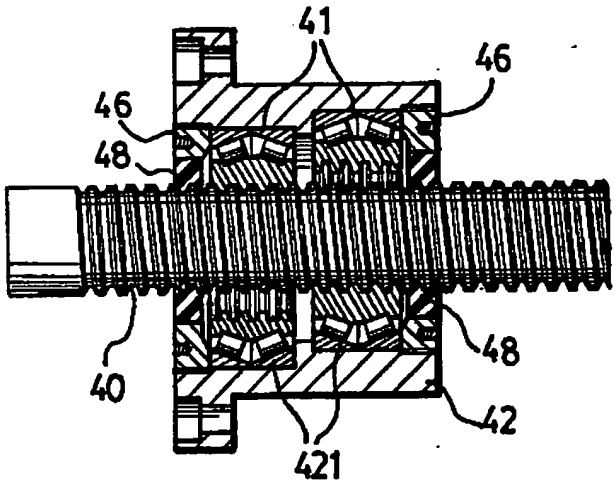
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Fig. 4

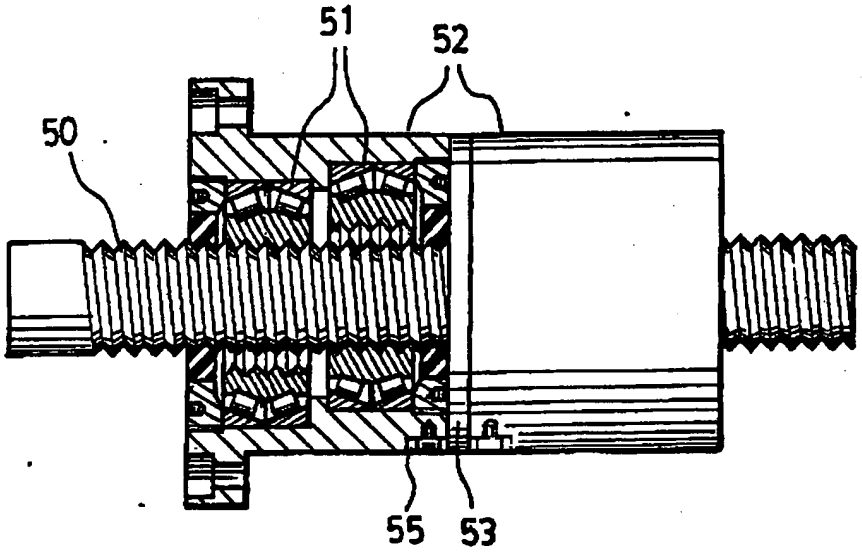

Fig. 5

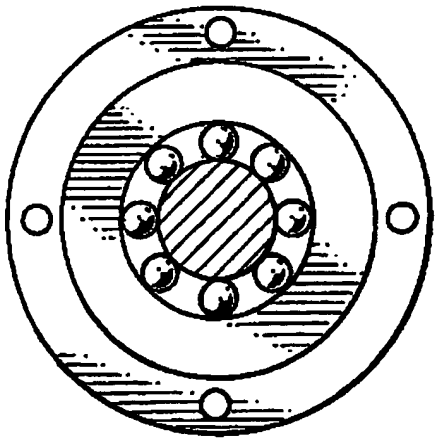

Fig. 6

(prior art)

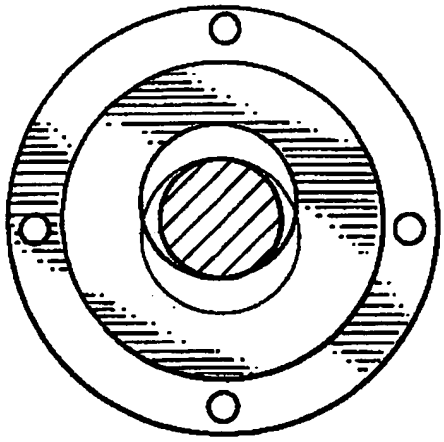

Fig. 7

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BEARING SCREW

BACKGROUND OF THE INVENTION

The invention relates generally to a screw assembly and in particular to such an assembly in which a nut with a pair of bearings disposed therein to be engagable with the thread of the screw. Such a bearing screw assembly has the advantages of low noise, reduce vibration, low operational temperature rise and long duty cycle.

Ball screws are known to be important mechanical elements. The ball screws have found broad use in industrial machines, computer numerical control machine tools and military armaments (such as aircraft, warships and missile guiding system). In general, a ball screw is composed of a screw member extending through a nut member which is movable along an axial direction of the screw member with a plurality of repeatedly recirculating balls rotatably and movably disposed therebetween. The recirculation of the balls may be classified as external recirculation and internal recirculation. The external recirculation makes use of an externally-mounted return tube for escorting the recirculation of the balls and thus is larger in size. On the other hand, the internal recirculation system comprises a return passage in the form of recessed slot on the nut member for guiding the recirculation of the balls so that the size thereof is smaller but the cost thereof is higher. Though the application of the ball screws is very broad, the ball screw still has the following disadvantages:

(1) The cross-sectional shape of the groove portion of the thread of both the screw member and the nut member is generally semi-circular or Gothic type and practically it is very difficult to provide

curvatures exactly the same at every point along the groove portion of the thread so that the manufacturing cost thereof is increased without an equivalent improvement in precision.

(2) The design principle of the ball screw is to take advantage of the rotation and translation movement of the balls and thus the groove portions of the threads are in the form of semi-circular or Gothic type, either one of which, however, provides only a small contact area of the balls with both the screw member and the nut member and thus possessing a poor load capability.

(3) The number of balls should be large and the overall length of the nut member be increased, for the load capability of the ball screw assembly is in principle dependent upon the total contact area of the balls, but the elongation of the nut member is not unlimit for a single nut member because it is difficult to make an internal thread in a long single nut.

(4) Recirculation of the balls is required and such recirculation usually leads in an un-acceptable mechanical efficiency when the balls leave or enter the threads of the screw member and the nut member so that high speed recirculation is not possible and high noise, high operational temperature rise, thermal deformations and abrasion between the balls are readily induced.

There are also roller screws conventionally used in industries. The roller screw comprises a screw member extending through a nut member which is movable along an axial direction of the screw member with a plurality of threaded rollers interposed between the screw member and the nut member in an equally-spaced manner around the circumference of the screw member and engagable with both the threads of the screw member and the nut member. It is to be noted that all types of

ball screw the load is transmitted from screw member to nut member through each ball. According to Hertz's law, the load carrying capacity of each ball is a function of its diameter. But, in a conventional ball screw the ball diameter can never be larger than the lead of the screw normally 60% to 70% of the lead. The load carrying capacity of a high efficiency screw also depends on the number of contact points. Thus, the roller screw has a considerably larger load capacity than the previously-described ball screw. However, according to statistic data, the roller screw takes only a share of 10% of the market while the ball screw occupies 90% of the market. In addition to cost and manufacturing technique problems, the reasons that the roller screw is not preferred are:

(1) The rollers which are supposed to be in perfect rolling motion within the threads of the screw member and the nut member may have sliding movement with respect to the screw member and the nut member when the axial movement thereof is fast so that the helical angle of the threaded rollers should be small enough and this limits the lead thereof. To overcome the problem, a planetary gear type roller arrangement is developed on the roller screw but the cost thereof is quite expensive.

(2) When the roller screw is used in a large lead condition, the contact area between the rollers with both the screw member and the nut member is reduced so that the load capacity is also reduced and due to the limited space within the nut member, it is not ready to increase the diameter of the threaded rollers and the intention to deepen the threads is also challenged by the weakening in structural strength of the thread and, as a consequence, the roller screws with larger leads have a weaker structure.

(3) The speed of axial movement of the nut member with respect to the screw member is proportional to the lead of the threads thereof and in order to increase the speed, multiple threads may be adapted in, for example, the screw member is with double thread while the rollers remain with single thread but this increases the manufacturing cost.

To this point, it can be understood that the precision and load capability of the roller screw are dependent upon the engagability of the threaded rollers with the threads of both the screw member and the nut member. The multiple-threaded screw member mated by the single-threaded rollers, although possessing advantage in speed, is expensive in manufacturing cost and has practical difficulty in achieving a high precision.

SUMMARY OF THE INVENTION

In view of the deficiencies of the prior art ball screw and roller screw, there is disclosed herein a bearing screw to fit Hertz's law, and the primary object of the present invention is to provide an improved screw structure which possesses the advantages of low operational temperature rise, low noise and reduced vibration. The bearing screw comprises a screw member with external thread thereon extending through a nut member which has a pair of bearings disposed within a through hole thereof to allow the penetration of the screw member therethrough. Each of the bearings has an inner ring with a plurality of annular grooves formed thereon to be in correspondence to and partially engagable with the external thread of the screw member. Each respective inner ring of the bearings has an inner diameter larger than the external or major diameter of the externally-threaded screw member and with the bearings non-aligned with each other and eccentric to

the screw member, that is, the inner rings of the bearings engage with the screw member from different directions.

Another object of the present invention is to provide a bearing screw wherein the screw member is locally pre-loaded by the nut member along arcuate contact curves and the arcuate contact area thereof is larger than the point contact of the conventional ball screw or the line contact of the conventional roller screw so as to provide a larger load capacity.

A further object of the present invention is to provide a bearing screw wherein the inner diameter of the inner rings of the bearings disposed within the nut member is larger than the external or major diameter of the externally-threaded screw member so that due to the difference in the peripheries thereof, a full turn of the screw member will not cause the bearings to rotate a full turn and thus it is possible to change the axial speed of the nut member relative to the screw member without modifications done on leads thereof and as a consequence, it is possible to accommodate a very fine lead condition with a suitable arrangement between the external or major diameter of the externally-threaded screw member and the inner diameter of the inner rings of the bearings disposed within the nut member.

These and other objects, advantages and features of the present invention will be more fully understood and appreciated by reference to the written specification and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a conventional ball screw with a portion thereof broken to illustrate the inside structure thereof;

Fig. 2 is a perspective view of a conventional roller screw with a portion thereof broken to illustrate the inside structure thereof;

Fig. 3 is a cross-sectional view of a bearing screw constructed in accordance with a first embodiment of the present invention;

Fig. 4 is a cross-sectional view of a bearing screw constructed in accordance with a second embodiment of the present invention;

Fig. 5 is a cross-sectional view of a bearing screw constructed in accordance with a third embodiment of the present invention;

Fig. 6 is a schematic view showing the contact area between the rollers and the screw member of a conventional roller screw; and

Fig. 7 is a schematic view showing the contact area between the bearings and the screw member of a bearing screw constructed in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Fig. 1 wherein a known ball screw is shown, the ball screw comprises a screw member 10 which is an externally-threaded rod and a nut member 12 which has an internally-threaded to be engagable by the screw member 10. In general, the nut member 12 is mounted or secured on a frame of a machine (not shown) in which the ball screw assembly is installed while the screw member 10 is to be rotated to move the nut member 12 along an axial direction thereof. A plurality of balls 14 are movably disposed within a helical passage defined between and by the threads of the nut member 12 and the screw member 10. A return tube 16 which constitutes a recirculation passage is mounted on the nut member 12 in a substantially tangential way and is secured by a retainer plate 18. When the screw member

10 is rotated along the axis thereof, by the guiding of the return tube 16, the balls 14, in turn, move from one end of the nut member 12 to the opposite end of the nut member 12 so as to induce an axial movement of the nut member 12 with respect to the screw member 10. However, due to the sudden change in direction of path when the balls 14 are recirculated from the helical passage into the return tube 16 or vise versa, a great amount of energy is lost and noise and heat are induced. As a result, the mechanical efficiency of the ball screw assembly is reduced.

In Fig. 2, a known roller screw is shown which comprises an externally-threaded screw member 20 and an internally-threaded nut member 22 to allow the screw member 20 to penetrate therethrough. A plurality of rollers 24 (preferably 6 or 8 in number), each comprising a male thread formed thereon, are interposed between the screw member 20 and the nut member 22 in an equally-spaced manner around the circumference of the screw member 20. Each of the threaded rollers 24 has two opposite ends respectively held in position by a retainer ring 26 disposed at each of two opposite ends of the nut member 22. By the rotation of the screw member 20, an axial movement is induced on the nut member 22, together with the rollers 24, relative to the screw member 20. The roller screw is best fit for the applications of small leads, but the manufacturing cost thereof is quite expensive.

With particular reference to Fig. 3 wherein a bearing screw constructed in accordance with a first embodiment of the present invention is illustrated, the bearing screw comprises a screw member 30 which has an external unified thread, a nut member 32 having a through hole to allow the screw member 30 to extend therethrough along the center axis thereof and a pair of ball bearings 31, preferably double-row ball

bearings with independent outer rings 311, sandwiched between the screw member 30 and the nut member 32. The through hole of the nut member 32 has two expanded ends to define a pair of recesses 321, which are not aligned with each other and corresponding in size to the ball bearings 31, for respectively receiving therein the ball bearings 31. The recesses 321 are eccentric from the center axis of the nut member 32 and thus the screw member 30 engages with the ball bearings 31 for an equal amount but in different directions, preferably opposite directions. A retainer ring 36 is disposed at each of the ends of the nut member 32 to contactingly abut against and thus securing the ball bearing 31 within the recess 321 of the nut member 32. A plurality of annular grooves 313 corresponding to the external thread of the screw member 30 are formed on each of the inner rings 312 of the ball bearings 31 and the inner diameter of the inner rings 312 is greater than the outer or major diameter of the screw member 30. The screw member 30 extends through the ball bearings 31 and partially contacts the annular grooves 313 of the ball bearings 31 along the different or opposite directions of eccentricity and thus respectively engaging the annular grooves at the different or opposite contact areas and, as a consequence, the screw member 30 is pinched between the ball bearings 31. Further, a ring-like cover member 38, which has an inner threaded through hole 381 engagable with the external thread of the screw member 30, can be disposed on the center hole of the retainer ring 36 to completely seal the recesses 321 and thus the ball bearings 31 from the exterior environments so as to seal the lubrication for the nut member 32 therein without leakage and preventing dirt or contamination from entering into the inside of the nut member 32.

With reference to Fig. 4, wherein a second embodiment of the present invention is shown, the screw member 40 of the instant embodiment comprises an external ACME thread. Similar to the first embodiment described above, the nut member 42 comprises two non-aligned recesses 421 for receiving therein two bearings which instead of the ball bearings adapted in the first embodiment are double row roller bearings 41. Also similar to the first embodiment, there are provided a pair of retainer rings 46 and a pair of ring-like cover members 48 with inner threads engagable with the external thread of the screw member 40. The purpose of the description of the second embodiment is to illustrate that the present invention can be applied in both unified thread and ACME thread so that it may accommodate different applications of different load requirements.

With reference to Fig. 5, wherein a third embodiment of the instant invention is illustrated to show the double nut arrangement as that used in the prior art ball screw or roller screw, the externally threaded screw member 50 is provided with two nut members 52 movably mounted thereon. The nut members 52 juxtapose with each other with a spacer 53 interposed therebetween and secured together with a securing plate 55, just as what is done in the prior art. Inside each of the two nut members 52, two roller bearings 51 (only those of the left hand side nut member in Fig. 5 are shown) are inserted and the disposition of the nut members 52 is such that the bearings 51 of the two nut members 52 are alternately disposed with respect to those of the other nut member in order to provide an even distribution of load.

Conventional roller screws as that shown in Fig. 2 are designed for large load operation. In Fig. 6, the contact condition between the screw member of a roller

screw assembly and the rollers thereof is shown. The rollers which surround the circumference of the screw member are in line contact with the screw member. The number of the rollers is usually six or eight, depending upon the requirements of load and size. In Fig. 7, the contact condition of the screw member with the bearings of the bearing screw constructed in accordance with the present invention is illustrated. In the present invention, the contact between the screw member and the bearings is in a curved form and the contact area of the curved condition is larger than that of the line contact of the conventional roller screw so that the bearing screw made in accordance with the present invention is capable of an even larger load operation.

Of course it is understood that the above is merely a preferred embodiment of the invention and that various changes and alterations can be made without departing from the spirit and broader aspects thereof as set forth in the appended claims.

CLAIMS

1. A bearing screw comprising:

a screw member which has an external thread;

a nut member which comprises a through hole to allow the penetration of said screw member therethrough along a center axis thereof, said through hole having two expanded end openings to form a pair of recesses, said recesses being offset with each other and eccentric from the center axis of said nut member; and

a pair of bearings which are respectively disposed in said recesses and each comprising an inner ring with a plurality of annular grooves formed thereon to engage the external thread of said screw member, each of said inner rings having an inner diameter larger than a major diameter of the external thread of said screw member so that the annular grooves of said bearings thus partially engage with the external thread of said screw member from different directions to pinch said screw member therebetween.

2. A bearing screw as claimed in Claim 1 wherein each of said bearings partially engages with said screw member along opposite sides thereof.

3. A bearing screw as claimed in Claim 1 wherein said bearings are double-row ball bearings.

4. A bearing screw as claimed in Claim 1 wherein said bearings are double-row roller bearings.

5. A bearing screw substantially as hereinbefore described with reference to and as illustrated in Figure 3 or Figure 4 or Figure 5 and Figure 7 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report) -12-

Application number
GB 9309329.2

Relevant Technical fields

(i) UK Cl (Edition L) F2Q

(ii) Int Cl (Edition 5) F16H

Search Examiner
A HABBIJAM

Databases (see over)
(i) UK Patent Office

(ii)

Date of Search
6 AUGUST 1993

Documents considered relevant following a search in respect of claims 1-5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1281143 (WAHLMARK SYSTEMS) see for example Figures 14 and 15 but whole document very relevant	1,2,3,4
X	GB 790487 (ROLLS-ROYCE LTD) see in particular Figures 1,9 and 11	1,2
A	EP 0122596 A1 (BETZING) see especially Figure 1	1,3
A	US 4856356 (GARTNER) equivalent to EP 0247417 See Figure 1 in particular	1,2
A	US 4322987 (GARTNER) equivalent to EP 0034640 See especially Figure 3	1,2

Category	Identity of document and relevant passages - 13 -	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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